Chapter 10
Packaging, Transportation, and Labeling of Low-Level Radioactive Waste

10-1. Packaging

a. Class A waste packaging. Class A wastes are required to meet only the minimum requirements for waste form set forth in 10 CFR 61.56. Thus, Class A waste has been disposed of at Barnwell and Hanford in steel boxes and 200-ℓ (55-gal) drums. Solid materials such as wood and metal are disposed of without a container. Boxes and drums suitable for Class A waste can be bought or leased from a variety of vendors.

b. Class B and C waste packaging.

(1) Structural stability. In addition to the minimum requirements, Class B and C wastes are required to have structural stability. Structural stability is necessary to inhibit (a) slumping, collapse, or other failure of the disposal unit resulting from degraded wastes which could lead to water infiltration, radionuclide migration, and costly remedial care programs, and (b) radionuclide release from the waste form that might ensue due to increases in leaching that could be caused by premature disintegration of the waste form. To the extent practical, Class B and C waste forms should maintain gross physical properties and identity over a 300-year period. To ensure that Class B and C wastes will maintain stability, the following conditions should be met:

(a) The waste should be in solid form or in a container or structure that provides stability after disposal.

(b) The waste should not contain free-standing and corrosive liquids. The waste should contain only trace amounts of drainable liquid, and in no case may the volume of free liquid exceed 1 percent of the waste volume when wastes are disposed of in containers designed to provide stability, or 0.5 percent of the waste volume for solidified wastes.

(c) The waste or container should be resistant to degradation caused by radiation effects.

(d) The waste or container should be resistant to biodegradation.

(e) The waste or container should remain stable under the compressive loads inherent in the disposal environment.

(f) The waste or container should remain stable if exposed to moisture or water after disposal.

(g) The as-generated waste should be compatible with the solidification medium or container.

(h) If the container is airtight and the waste has alpha emitters, the helium gas produced could cause high pressure in the container, so relief values should be provided.

(2) High integrity containers.

(a) Introduction. An alternative to processing some Class B and C waste streams is the use of a high-integrity container (HIC). The HIC would be used to provide the long-term stability required to meet the structural stability requirements in 10 CFR 61. Use of an HIC can provide a convenient and economical means for handling, transporting, and disposing of low-level waste. The NRC, in the Revised Staff Technical Position on Waste form (NRC 1991) issued the following requirements for HICs:

The maximum allowable free liquid in an HIC should be less than 1 percent of the waste volume.

HICs should have as a design goal a minimum lifetime of 300 years.

The HIC design should consider the corrosive and chemical effects of both the waste contents and the disposal environment.

The HIC should be designed to have sufficient mechanical strength to withstand horizontal and vertical loads on the container equivalent to the depth of proposed burial assuming a cover material density of 120 lb/ft^3 (1,920 g/ℓ). The HIC should also be designed to withstand routine loads and effects from the waste contents, waste preparation, transportation, handling, and disposal site operations, such as trench compaction procedures. This mechanical design strength should be justified by conservative design analyses.

It should be demonstrated for HICs fabricated from polymeric materials that the containers will not undergo tertiary creep, creep buckling, or dutile-to-brittle failure over the design life of the containers.

The design should consider the thermal loads from processing, storage, transportation, and burial. Proposed container materials should be tested in accordance with ASTM B553 (ASTM 1979a). No significant changes in material design properties should result from this thermal cycling.

The HIC design should consider the radiation stability of the proposed container materials as well as the radiation degradation effects of the wastes. Radiation degradation testing should be performed on proposed container materials using a gamma irradiator or equivalent. No significant changes in material design properties should result following exposure to a total accumulated dose of 10^8 rads. If it is proposed to design the HIC to greater accumulated doses, testing should be performed to confirm the adequacy of the proposed materials. HIC designs using polymeric materials should also consider the effects of ultraviolet radiation. Testing should be performed on proposed materials to show that no significant changes in material design properties occur following expected ultraviolet radiation exposure.

Biodegradation testing should be performed on proposed container materials in accordance with ASTM G21 and G22 (ASTM 1970, 1976). No indication of culture growth should be visible. It is also acceptable to determine biodegradation rates using the Bartha-Pramer method. The rate of biodegradation should produce less than a 10-percent loss of the total carbon in the container materials after 300 years.

The HIC should be capable of meeting the requirements for a Type A package as specified in 49 CFR 173. Conditions that may be encountered during transport or movement are to be addressed by meeting the requirements of 10 CFR 71. The HIC and the associated lifting devices should be designed to withstand the forces applied during lifting operations. As a minimum, the container should be designed to withstand a 3-g vertical lifting load.

The HIC should be designed to avoid the collection or retention of water on its top surfaces in order to minimize accumulation of trench liquids which could result in corrosive or degrading chemical effects.

HIC closures should be designed to provide a positive seal for the design lifetime of the container. The closure should also be designed to allow inspections of the contents to be conducted without damaging the integrity of the container. Passive vent designs may be utilized if needed to relieve internal pressure. Passive vent systems should minimize the entry of moisture and the passage of waste materials from the container.

Prototype testing should be performed on the HIC.

HICs should be designed, fabricated, and used in accordance with a quality assurance program. The quality assurance program should address the following topics concerning the HIC: fabrication, testing, inspection, preparation for use, filling, storage, handling, transportation, and disposal. The quality assurance program should also address how wastes which are detrimental to HIC materials will be precluded from being placed into the container.

(b) Types of HICs. HICs can be made of polyethylene, polyethylene coated with fiberglass, stainless steel, polymer-encapsulated carbon steel, or Enviroalloy. The polyethylene HICs are usually disposed of within a concrete overpack.

(c) Scientific Ecology Group, Inc. (SEG) offers the RADLOK® HIC, which is constructed of high-density, cross-linked polyethylene and is designed to fit the cavity of the SEG transportation cask. SEG also offers a BARRIER PLUS™ package, which is a stainless steel shell with a polyethylene lining. Steel radwaste containers can be obtained from SEG. Many SEG containers can be supplied with underdrains for dewatering.

(d) Pacific Nuclear Systems' NuPac Services offers an HIC made of Enviralloy™. Enviralloy™ is a duplex alloy of Ferralium-255. The manufacturer claims that these containers are highly resistant to corrosion, are impervious to ultraviolet radiation, resist pitting, and have a design life of 500 years. The Enviralloy™ container family consists of seven variously sized containers that provide three closure options and a 200-ℓ (55-gal) container, a single 200-ℓ (55-gal) drum overpack, and a double 200-ℓ (55-gal) drum overpack, which have gasketed closures. The Enviralloy™ containers can only hold dewatered wastes. Pacific Nuclear also offers polyethylene HICs, which can be outfitted with dewatering systems and carbon steel liners.

(e) SEG and Pacific Nuclear were the only vendors that could be contacted that provide HICs. Others may do so and should be contacted when specific needs are determined. If containers are reused, they must be decontaminated as discussed in Section 8-3.

10-2. Transportation and Labeling

a. Transportation of radioactive waste.

(1) Regulations. The regulations that impact the transportation of radioactive waste are 49 CFR 172-177 (specifically 49 CFR 173, which contains the Hazardous Materials Regulations based on the United Nations Committee of Experts recommendations on the transport of dangerous goods), 10 CFR 71, and 10 CFR 20. The EPRI document, "Radwaste Desk Reference, Vol 2: Transportation and Disposal (EPRI 1992), " contains detailed discussions of the transportation requirements for LLRW.

(2) De minimis level. Department of Transportation (DOT) regulations define radioactive material as "any material having a specific activity greater than 0.002 uCi/gram. " Below this concentration limit, a material is not regulated as a radioactive material while in transport. NRC regulations express this same provision as an "exemption" from the 10 CFR 71 requirements.

(3) Types of radioactive packages. The principal types of packages as defined in 49 CFR are as follows:

(a) Excepted packages (also called "strong, tight packages").

(b) Type A packages.

(c) Type B packages.

(d) Fissile packages (both Type A and Type B).

These package categories are distinguished by the quantity of radioactive material. Each package category has a set of shipping and labeling requirements that are discussed in 49 CFR 173.

(4) Transportation methods. Radioactive material can be transported by ground transportation. Quadrex, SEG, and others offer tractor-trailer transportation services to clients. SEG uses a nationwide satellite communication and tracking system to be able to pinpoint the location of their drivers 24 hr a day.

(5) Transportation casks. Quadrex and NSSI offer shielded transportation casks. Casks are rated based on the quantity of radioactivity, activity concentration, or both. Cask designations are the same as package designations.

(6) Driver exposure. The dose to the driver is an extremely important concern in the shipment of radioactive wastes. The occupational dose limit was used as a basis for calculating the quantity of wastes allowed in the transportation packages. The waste must be arranged in the truck so that the driver is not overexposed.

(7) Exclusive use shipments. The term "exclusive use" is used to describe a shipment of radioactive materials in which the following conditions apply.

(a) All of the packages in the shipment must originate from a single shipper.

(b) The packages must be loaded, blocked, and braced by that same shipper.

(c) Any off-loading while enroute or at the final destination must be done by or at the direction of either the shipper or the recipient. Such off-loading must be done by persons having appropriate radiological control training.

Regulations governing exclusive-use shipments are outlined in 49 CFR 173.

(8) Radiation limits. Radiation limits are discussed in 49 CFR 173 and are summarized below in Table 10-1. The radiation limit is 200 mrem/hr at the package surface, except in the case of a closed transport vehicle where the position is fixed and there are no intermediate loadings or unloading. There are also thermal limits and contamination limits as detailed in 49 CFR 173.442 and 173.443, respectively.

Table 10-1
Radiation Limits for Waste Transportation

Location	Limits (mrem/hr)
Package surface	200
Package surface in inclosed vehicle	1,000
2 m from outer lateral surface of vehicle	10
Normal occupied area of vehicle (does not apply to private carrier personnel with radiation dosimetry)	2
Non-exclusive use carrier	TI

Note: Transport index (TI) is the radiation level at 1 m from the external surface of the package.

(9) Manifests. The following minimum information is required on manifests:

(a) Basic shipping description.

Proper shipping name (from 49 CFR 172. 101).

Hazard class (from 49 CFR 172. 101).

ID # (from 49 CFR 172),

Total quantity of material by weight or volume.

(b) NRC approval code required on shipping container.

(c) The quoted certification statement from 49 CFR 172.204.

(d) If mixed waste, hazardous waste manifests must also be utilized.

b. Labeling of waste packages.

(1) 10 CFR 61 Requirements. 10 CFR 61.57 requires each Package F waste to be clearly labeled to identify whether it is Class A waste, Class B waste, or Class C waste.

(2) DOT requirements. 49 CFR 172 requires each waste package to be labeled with:

(a) Proper shipping name.

(b) UN hazard identification number.

(c) Name/address of the consignor or consignee.

(d) Type A, Type B, DOT specification No., NRC certificate or DOE certificate identification No., as appropriate.

(e) “This side up, ” “This end up, ” or arrows, if a liquid.

(f) “RQ” if it is a “reportable quantity” as given in 49 CFR 172.

These markings do not apply to excepted packages.

(3) Radioactive labels. The three categories of radioactive labels are Radioactive-White I, Radioactive-Yellow II, Radioactive-Yellow III, in order of increasing radiation level at the surface of the package. The category of label depends primarily on the radiation levels at the surface of the package and at 1 m from the package. 49 CFR 172 contains a table which can be used to determine the proper package label category.